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Of the above noted eighty species of Cicindelidæ thirty* occur in the United States, four species (*Cicindela trifasciata* F., *flavopunctata* Chev., *carthagera* Dej. and *Tetracha carolina* L.) are known from the United States, Mexico and countries south of Mexico. The species with the widest geographical distribution is the last one, which runs down to the north of Chile. The four tropical genera (*Ctenostoma*, *Hiresia*, *Beckerium* and *Odontochila* represented all together only by five species!) belong all to the extreme south of Mexico (south of Vera Cruz).

THEORY AS TO EVOLUTION OF SECONDARIES OF MOTHS OF THE GENUS CATOCALA.†

ARCHIBALD C. WEEKS.

The conspicuous beauty of the secondaries of the members of this genus, the delight and admiration of every collector, is so wonderfully and handsomely differentiated from that of their plainer congeners of the noctuidæ as to entitle it to some speculation as to its origin. Although there is something to admire in the colorative arrangement of the subdued and modest hues of the species of allied genera, nevertheless, in both primaries and secondaries of the latter prevail shades ranging from black, brown, pale yellow, red, green and gray to white, all calculated to make their wearers invisible by reason of their more or less perfect blending with the color scheme of earth, rocks, and dead or living vegetation, and so escape observation of enemies and perpetuate their species. The *Catocala*, however, though provided with primaries similarly marked and obviously for the same purpose yet possess secondaries adorned with brilliant red, scarlet, magenta, pink, yellow, blue, black or white, as startling a contrast of vestiture as could possibly be imagined. Instead of a coloration developed along the lines of agreement or identification with environment we here find one which apparently scorns concealment and openly and

* 29, if *Cicindela sommeri* Mann. would not belong to the fauna of the United States.

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boldly declares its owner, inviting attention and daring and braving attack and capture. Such coloration by way of distinction may be termed "aggressive or hostile" as opposed to passive where the colors copy and blend with surrounding objects, the terms "aggressive" and "passive" being understood to be merely relative and to imply no special consciousness or instinct. It would seem a fair question to ask what environment or circumstance of natural selection could have produced a decoration so variant and which must necessarily have been acquired under substantially the same conditions as that of other noctuids. Although North America is virtually the home of the *Catocala*, species of this genus, or at least species having a similar scheme or plan of maculation occur almost universally, among which may be mentioned the *Ophiderides* of India and Java, while hosts of unrelated genera also possess lower wings far more attractive and conspicuous than the upper, and, therefore, whatever theory may be offered in explanation of this characteristic in the *Catocala* would apparently apply equally to the others. Since the problem of the origin of aggressive coloration does not appear at first glance to be directly demonstrable, a more satisfactory method of solution may be obtained indirectly by considering the circumstances under which certain forms of the secondaries have been developed and the uses to which they are applied, since, however remarkable the contrast of hues between the upper and lower wings, it is not more peculiar and surprising than the apparently abnormal secondaries of many other groups of lepidoptera to which tails are attached, moderately among the papilios, graptas, theclas, certain hesperians and many others, or extraordinarily, as in the case of *Actias luna* and allied species. The theory has been advanced and it seems quite a reasonable one that development by prolongation of the lower wings in the form of tails, abnormal and apparently unnecessary as it is, is really a factor of high value as a means of preservation of an insect from destruction by its enemies. Again and again may predatory bat or bird, in an effort to capture a moth or butterfly, successively tear away sections of the tails, of which a sacrifice can be readily afforded, without disabling it or retarding its flight.

The abnormal development of these appendages or tails seems to have originated from the fact that whenever, in the course of natural variation, certain individuals have been congenitally provided with secondaries unduly enlarged, these individuals by reason of being pos-

sessed of more wing to sacrifice had just so much more chance to escape, while those possessed of abbreviated wings would in the ordinary course of existence be first destroyed, and consequently those individuals inheriting a tendency to enlargement of the secondaries would be most likely to survive and transmit their structural peculiarities to their descendants until the character became fixed and permanent. Such development, of which the secondaries of the luna moth are an example, is directly opposed to the common understanding that wings should be as compact as possible without unnecessary appendages and thus facilitate escape by rapid flight. If, therefore, it be deemed reasonable and well proved that aggressive formation has developed through its protective qualities, why is it not quite as reasonable to assume that aggressive coloration has originated under similar circumstances and for a similar purpose, viz.: to divert the attention of a pursuer to the conspicuous, vividly-colored, attractive-appearing secondaries, whereby the plainer, uncolored and unattractive but vital parts escape injury. This result would undoubtedly be obtained along the lines of natural experimental variation and varietal production, those individuals having brighter, more striking, or more attractive-appearing secondaries being most likely to escape for the reason that the attention of an enemy would ordinarily be diverted to these showy but non-vital portions, and, as in the case of the luna moth and other species with tailed secondaries, the individuals thus escaping would be enabled to propagate and so bequeath their excess of coloration for fuller development. In the course of a long series of generations a constant elimination of the duller-hued individuals as being the first captured and an equal survival from capture of the brighter forms would inevitably tend to the abnormal development of highly colored secondaries such as we find in the members of the genus *Catocala* to-day, and will, I think, be accepted as a reasonable solution of the origin of the extraordinary and apparently inexplicable departure in coloration of the members of this genus from those of kindred genera. The fact that there are now so many species, all variant in color and maculation by bands or stripes, works no contradiction to this theory. Granted that in the far distant past there was a primitive ancestor in whose secondaries slight suggestions of bands might appear, it is easy along the lines of development to obtain more pronounced variations, and the several species are simply the variant forms which always arise under favorable or unfavorable environ-

ments, including supply, scarcity and variety of plant food, temperature, interbreeding, etc.

The above conclusion that the conspicuous colors of the secondaries are useful in diverting attention from the more vital parts seems to be confirmed by the habits and incidents in the life history of the *Catocala*. During the day these moths securely screen themselves from observation by selecting resting places more or less hidden on the bark of trees or other objects, the color of which is best adapted to harmonize and blend with the twilight shades of the upper wings, and with which they cover and conceal their prominently marked lower ones. At night, however, unless resting or sated with juices, this practice is almost always reversed, and the brilliantly hued lower wings are displayed to their utmost extent, rendering them in contrast with their surroundings visions of surpassing and impressive beauty. These colors could not have been developed in vain, and although except by artificial means we are denied the pleasure of beholding them, we must remember that in the lower world there are myriads of eyes whose powers are far superior to our own and it is not credible that the joyous colors of the day are forbidden them when the sunlight has vanished. A further confirmation of the theory is furnished by the fact that one of the most discouraging features in collecting these moths is the difficulty of obtaining specimens the secondaries of which are perfect. It is a common experience to find either one or both of these wings badly marred, mutilated, or partly missing, while the primaries are almost invariably intact. The freshest as well as the eldest specimens are equally thus injured, which certainly affords strong evidence that the secondaries are chiefly the objects of attack.

An exception to the concealment of the secondaries may be noted which still further confirms the above theory as to their origin and development. Should the insect be compelled, by reason of lack of suitable ground, trees, rocks or other similar objects whereon to rest and match the sober markings of the fore wings, to light among the grass, weeds and leaves where there are myriad streaks or bands of light and shade it will often, especially of the yellow-banded species, drop down with the wings partially opened as if by the exhibition of its own stripings to match its surroundings. Within a short time, however, it will crawl closer to the ground beneath the sheltering grass and other herbage and there fold its wings. A genus of small

moths closely allied to the *Catocala* is *Syneda*. Insects of this genus have pale yellow, transversely marked secondaries. Their habitat and methods of concealment also furnish suggestions as to the origin of this method of maculation by stripes as a protective character by coincidence with environment. These moths occur in sandy localities where there is practically, to the ordinary view, but little opportunity for concealment, the surface of the ground being principally bare and interspersed with patches of stunted and sparse vegetation not more than a few inches in height, and strewn around which in different directions lie masses or little heaps of dead grass, or other fragments of withered plants. The moth generally rests upon the ground in close proximity to small sticks, stones or where the darkened sand and earth correspond more nearly with the general coloration of the fore wings. Its most common attitude at the moment of alighting is with wings expanded so as to match their stripings and maculation with the mottled and banded appearance presented by small differently colored stones and grass. Shortly afterward the fore wings slowly close over the hind wings which still better match the surroundings and render the moth invisible to the ordinary eye. The stripings on all animals are a characteristic, generally admitted to be useful in concealment from observation, as the vertical stripes on the zebra, tiger, etc., which correspond with the alternate lights and shadows of closely standing tree trunks or small stems of canes and other tropical vegetation. In the same way many of the moths which frequent grassy fields as the arctians, for instance, have wings striped longitudinally with the evident intent of matching the light and dark hues caused by the appearance of the light spaces between the plant stalks. We may fairly infer therefore that the ancestor of the *Catocala* was an insect which originally acquired its protective stripings merely for the purpose of concealment by harmonizing and blending with its environment, and that aggressive coloration was a subsequent acquisition which was improved and encouraged in the same proportion as its value as a protective factor increased.

We have still another form in various other families where the secondary is provided with a large and prominent ocellus or eye-shaped figure. Whether this be for the purpose of counterfeiting the eyes of some predatory bird or animal and thus causing fear or whether these pronounced eye-like spots are useful in diverting the attention of an enemy, might afford a question for discussion, but according to

analogy I should prefer the latter, and for this form of protective development I would coin a third term "aggressive maculation."

We have then six terms to express protective development, viz., passive or negative formation, maculation and coloration, and active, aggressive or hostile formation, maculation and coloration. For practical application of these terms we may confine ourselves to the lepidoptera. Among the noctuids in general, omitting the genus *Catocala* the entire family depends for concealment upon the two last divisions of the first class, viz., passive or negative coloration and maculation, while certain of the graptas by folding their wings with deeply indented margins furnish examples of all three divisions. Moths like the *Actias*, as our native luna, furnish examples of both passive coloration (in that the wings are of a delicate green shaded with white resembling many large leaves) while the projection rearward of its secondaries furnishes an example of aggressive formation, being thus doubly protected whether at rest or in flight. The *Catocala* are also doubly protected, but in a different way, the fore wings furnishing examples of passive coloration and maculation while the hind wings are models of aggressive coloration except in cases where they are employed under circumstances above named to blend with the alternate shadings of grass stalks and other herbage. The aggressive formation of the luna is for protection during flight while the aggressive coloration of the *Catocala* is principally for protection while at rest. It would be an interesting as well as an instructive exercise to examine the wing structure, coloration and maculation of numerous species and endeavor, in connection with such knowledge as can be gained concerning their life-histories, to trace the causes which probably produced the variations of each, in accordance with the classification above prescribed, taking into consideration nevertheless that all deductions are necessarily limited to such meager inference and knowledge as we may chance to possess of the varying environments to which previous generations have been subjected through myriads of ages. It must also be conceded that no result has been without object, but that every form with its accompanying shades and patterns of color has been evolved for a definite purpose in the course of the pitiless struggle for existence since the beginning, and remains more or less permanent though the circumstance which promoted its origin may have long since passed away.